

Kazuo SUZUKI*: **Biosystematic studies of Japanese
Epimedium (Berberidaceae)**

(1) Variation of the populations in Shikoku (Part 2)**

鈴木和雄*: 日本産イカリソウ属 (メギ科) の種生物学的研究

(1) 四国における集団の変異 (第2部)

Populations showing problematical affinity and/or variability. It has been confirmed that eight of the 23 populations studied can not be adequately referred to any one of the four representative types described above. In the eight populations were included the individuals which are deviated from "pure" species in the combination of morphological characteristics, or are intermediate in some features. The individuals, which can be identified to belong to one of the four species, were also mixed in most of the eight populations.

In the following descriptions which outline the population structure, individuals referable to "pure" species are represented by the initial of species name (e.g., *E. diphyllum* = D), and the individuals which show the morphological traits being laid across two species are denoted by the two initials connected by a hyphen. The number of samples observed is inserted in parentheses.

Koboshi (Fig. 8, 2): varying from D to K, also skewing to T: D (7); K (1); D-K (9), D in leaf hairiness and K in ramification and/or leaflet apex; nearly T (1), differing from typical T in having a shorter spur; D-T (2), D in ramification and T in spur development (though shorter than typical T) and leaflet apex.

Masahiro (Fig. 8, 3): varying from D to K: D (2); K (4); D-K (6), D in leaf hairiness and K in ramification and/or leaflet apex.

Tōzenji (Fig. 8, 5): close to K but faintly skewing to D: K (14); K-D (10), D in leaflet apex and K in other features.

* Makino Herbarium, Faculty of Science, Tokyo Metropolitan University, Fukazawa, Setagaya, Tokyo 158. 東京都立大学理学部牧野標本館. 東京都世田谷区深沢 2-1-1. 158.

** Continued from Journ. Jap. Bot. 53: 203-212 (1978).

Kagami-A (Fig. 8, 9): close to D but faintly skewing to T: D (3), D-T (7), T in leaflet apex and D in other features.

Kagami-B (Fig. 8, 10): intermediate between D and T though closer to D, variable: D (5); D-T (25), D in ramification and T in spur development (though generally shorter than typical T) and/or leaflet apex.

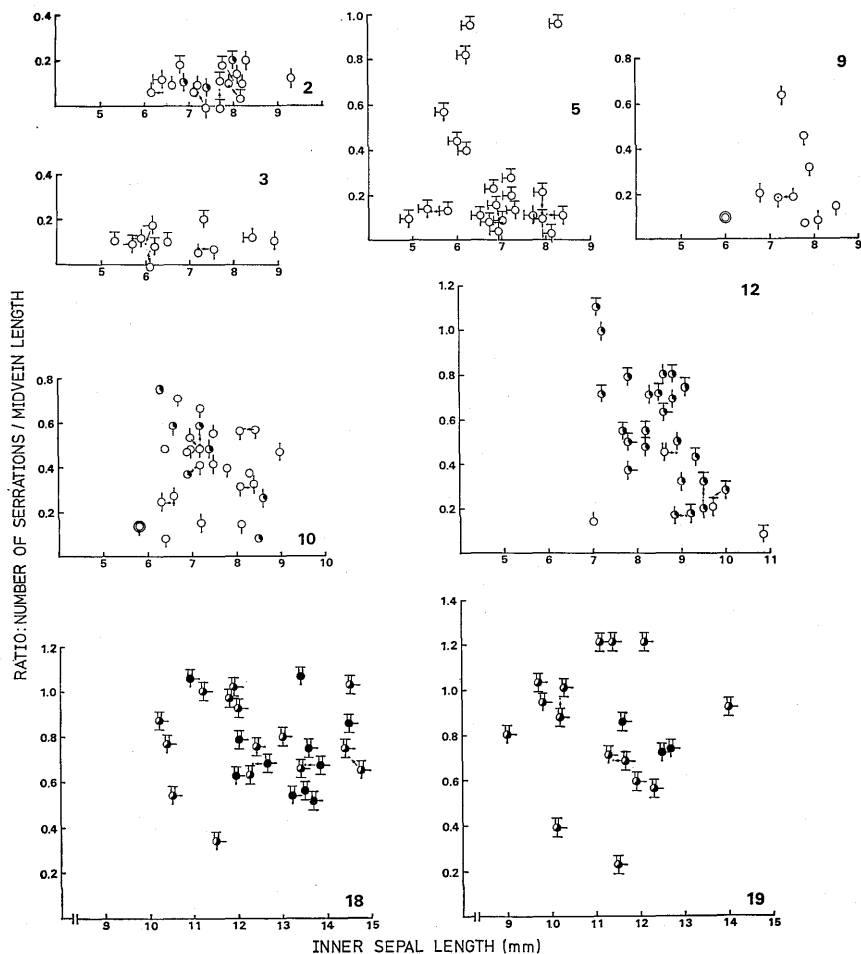


Fig. 8. Scatter diagrams showing the character correlation in the collections from eight problematical populations: 2, Koboshi; 3, Masahiro; 5, Tōzenji; 9, Kagami-A; 10, Kagami-B; 12, Aburaishi; 18, Sadanaga; 19, Funakoshi. (Legends for symbols as in Fig. 5).

Aburaishi (Fig. 8, 12) : intermediate between D and T though closer to T, variable: D(1) ; D-(T)-G (1), D in spur development, G in ramification and T (intermediate between D and G) in other features ; D-T (2), D in spur development, and T in ramification and leaflet apex ; nearly T (24), differing from typical T in having a shorter spur.

A herbarium specimen from Ioki (cf. Fig. 1 and Fig. 4) ; D-T, D in spur development and T in other features.

A herbarium specimen without a flower from Kuwao (cf. Fig. 1 and Fig. 4) ; T-G, T in leaflet apex, intermediate in leaf hairiness, and G in ramifica-

Table 3. Number of individuals showing respective pollen fertility.

Locality	Pollen fertility (%)						
	40-50	50-60	60-70	70-80	80-90	90-100	undeterminable
1. Mt. Iino	0	0	0	0	0	5	0
2. Koboshi	0	0	0	1	0	19	0
3. Masahiro	0	0	1	1	0	10	0
4. Kirihata	0	0	0	0	1	28	0
5. Tōzenji	0	0	0	1	0	23	0
6. Nishikata	0	0	0	2	4	14	0
7. Takano	0	0	0	0	0	8	0
8. Go-ōdō	0	1	1	0	0	15	1
9. Kagami-A	0	0	0	0	0	10	1
10. Kagami-B	0	0	0	0	5	25	0
11. Sako	0	0	0	0	1	17	0
12. Aburaishi	0	0	0	2	2	24	0
13. Okō	0	0	0	0	0	26	0
14. Ikku	0	0	0	0	0	21	0
15. Jinzenji	0	0	0	0	0	10	0
16. Engyōji	0	0	0	0	0	27	0
17. Fukui	0	1	0	0	0	22	0
18. Sadanaga	0	0	0	1	0	25	0
19. Funakoshi	0	0	0	0	0	20	0
20. Ōnogahara	1	0	0	0	2	20	1
21. Yamada	0	0	0	0	0	27	2
22. Izumi	0	0	0	2	1	10	11
23. Misaki	0	0	0	1	0	34	0

tion.

Sadanaga (Fig. 8, 18): intermediate between T and G, showing no individual of typical T or G but composed of the individuals having the following character-combinations (T and G are denoted below as the features of the corresponding taxon, and I means the intermediate trait between T and G; the characters are arranged in the order of the degree of spur development, leaf hairiness, type of ramification and shape of a leaflet apex): TIGG (11), TIGT (5), GIGG (4), GIGT (3), GTGT (1), TTGG (1).

Funakoshi (Fig. 8, 19): intermediate between T and G: no typical T nor G; composed of the individuals with the following character combinations (procedures as in the Sadanaga population): TIGG (12), TIGT (3), GIGT (2), GIGG (1).

Pollen fertility. Results of the examination of pollen are shown in Table 3. It is clear that most individuals in every population show over 80% in pollen fertility and that individuals with an aberrant character-combination in problematical populations show as high fertility as those in the populations of the representative types.

Discussion The present work has proved that populations of *Epimedium* in Shikoku can be divided into two kinds. One of them has a minor intra-population variability and consists of the populations which can be identified as belonging to one of the four representative types. The other kind of the populations is characterized by a larger intra-population variability. They are composed of the individuals which are referable to a representative type and some aberrant individuals or of aberrant individuals only.

Character-expressions found in such aberrant individuals strongly suggest that gene exchanges among the four types would have occurred. It is hardly imagined that the intra-population variability as noted in the Sadanaga population has been brought about through mutation or phenotypic plasticity. More or less similar variability within a population, which can be regarded as a reproductive unit (cf. Table 1), has been observed in seven other populations. It may be presumed that the gene-recombinations through hybridization have occurred.

As may be seen from Table 2 and Fig. 5, *E. diphyllum* and *E. grandiflorum* are contrasted in all the diagnostic characters, except the hairiness of the upper leaf surface (see below). The morphological features of these

two species can be regarded to represent the two extremes among plants of *Epimedium* in Shikoku. On the other hand, *E. kitamuranum* and *E. trifoliatobinatum* are intermediate between the two extremes in various features and approach to one of the two extremes in some other features. It may also be clear from Table 2 that *E. kitamuranum* is closer to *E. diphylum* while *E. trifoliatobinatum* to *E. grandiflorum*. In case of *Epimedium*, sterility barriers apparently do not operate to reduce introgressive hybridization, as evidenced by the fact that no appreciable reduction pollen- (Table 3) and seed-fertility has been detected in the aberrant individuals of various variable populations. All of these observations are in favor of the hypothesis advanced by some earlier authors (Stearn, 1938; Maekawa, 1955; Kitamura & Murata, 1961) that both *E. kitamuranum* and *E. trifoliatobinatum* may be of hybrid origin between *E. diphylum* and *E. grandiflorum*.

Mention should be made to the hairy upper surface of a leaf in *E. kitamuranum*. This trait is not found in any other plants of *Epimedium* in Shikoku, and it would seemingly contradict the assumption of the hybrid origin of *E. kitamuranum*. The hairs in question are, however, morphologically similar to the hairs on the lower surface of a leaf in *E. kitamuranum* and also in *E. diphylum* and *E. trifoliatobinatum* (Fig. 9). Morphological characteristics of hybrids are not always parental or intermediate, but transgressive segregation is known in various examples (Grant, 1975). The fact that only *E. kitamuranum* has the hairy upper leaf surface among the plants in Shikoku may therefore be not necessarily contradictory to the assumption of its hybrid origin.

Although the above hypothesis seems to be tenable, it is apparently desirable to verify it by experimental means. It must be noted that no population which is indicative of natural hybridization between *E. diphylum* and *E. grandiflorum* has been located in Shikoku. Under the assumption that *E.*

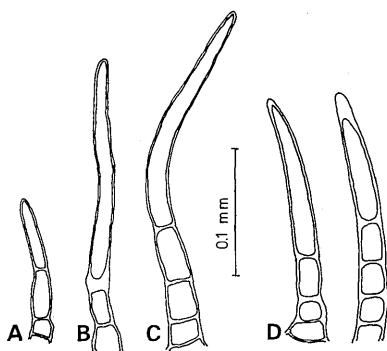


Fig. 9. Persistent hairs observed on a leaf:
A, *E. diphylum*; B, *E. kitamuranum*; C,
E. trifoliatobinatum; D, *E. kitamuranum*.
A-C, lower surface; D, upper surface.

kitamuranum and *E. trifoliatobinatum* are hybrid derivatives, studies must be extended to make clearer what environmental factors have contributed to sort out the plants referable to *E. kitamuranum* and *E. trifoliatobinatum* from the hybridizing populations. Edaphic factors may be regarded as part of such factors; "pure" populations of *E. trifoliatobinatum* are almost always confined to a site on serpentine rocks according to Yamanaka (1953a) and the present observation.

Evolutionary differentiation which seems not to be related with hybridization has been observed in *E. grandiflorum*. Populations of this species in eastern Shikoku (7 and 8) are characterized by a very short petiole length of a stem-leaf, while a population located in western Shikoku (20) has consisted of the individuals with much longer petiole. The former grows on limestone cliffs or slopes, while the latter occurs on a grassy karst plateau. These differentiation must have occurred in connection with geographical isolation, and hybridization seems not to have played a role. This subject, as well as various other subjects, should be studied further by adding analyses of populations in other regions and by approaches from other points of view. Studies along these lines are now in progress.

Acknowledgements I wish to express my deep gratitudes to Assoc. Prof. M. Ono of Tokyo Metropolitan University, for his kind guidance and encouragement. I am also indebted to Dr. T. Tateoka of Laboratory of Biosystematics, Department of Botany, National Science Museum, Ibaraki, who gave me valuable suggestions and critically read the manuscript. I am grateful to the directors and curators of the herbaria of KYO, MAK, TI and TNS who allowed me to examine the specimens. My thanks are due to Mr. T. Abe, Tokushima Pref. and Mr. N. Inagaki of Makino Botanic Garden, Kōchi City who kindly helped me in field collections and provided the materials.

References

- Grant, V. 1975. Genetics of Flowering Plants. Columbia University Press, New York. Kitamura, S. & G. Murata. 1961. Coloured illustrations of herbaceous plants of Japan II (Choripetalae). Hoikusha, Osaka. — & —. 1962. New names and new conceptions adopted in our coloured illustrations of herbaceous plants of Japan II (Choripetalae). Acta Phytotax. Geobot. 20: 195–208. Koidzumi, G. 1932. Contributiones ad cognitionem florae

asiae orientalis. Acta Phytotax. Geobot. 1: 11-33. —. 1936. Contributiones ad cognitionem florum asiae orientalis. Ibid. 5: 119-129. —. 1938. Floral region of the eastern part of Kii mountain range. Ibid. 7: 120-123 (in Japanese). —. 1939. Contributiones ad cognitionem florum asiae orientalis. Ibid. 8: 50-61. Koyama, H. 1965. Notes on the karyotypes of *Epimedium*. Acta Phytotax. Geobot. 21: 69-72. Maekawa, F. 1932. Alabstra diversa I. Bot. Mag. Tokyo 46: 582-584. —. 1955. Species problem and phylogenetic appreciation for diagnostic characters—A case of *Epimedium*. J. Jap. Bot. 30: 353-358. Makino, T. 1909. Observations on the flora of Japan. Bot. Mag. Tokyo 23: 134-150. —. 1931. A contribution to the knowledge of the flora of Nippon. J. Jap. Bot. 7: 13. Nakai, T. 1944. *Epimedium grandiflorum* et ejus affinitates, vel, species section Macroceras in Imperio Nipponico sponte mascentes. J. Jap. Bot. 20: 65-84. —. 1953. Opera phytologica novissima. Bull. Natn. Sci. Mus. Tokyo 33: 1-30. Ohwi, J. 1953. New names and new combinations adopted in my "Flora of Japan". Bull. Natn. Sci. Mus. Tokyo 33: 66-90. Shimizu, T. 1960. Notes on the vascular plants characteristic of the limestone area in the southern part of Pref. Kumamoto, Kyushu, Japan I. Acta Phytotax. Geobot. 18: 117-128. Stearn, W. T. 1938. *Epimedium* and *Vancouveria*, a monograph. Jour. Linn. Soc. 51: 409-534. Pl. 24-31. Yamanaka, T. 1953a. Notes on the some plants of Shikoku II. Acta Phytotax. Geobot. 15: 25-26. —. 1953b. Flora and vegetation of Mt. Ishidate, Shikoku. Ibid. 16: 120-125. —. 1959b. Serpentine Flora of Mt. Higashi-Akaishi, Shikoku, Japan. Ibid. 18: 80-96. —. 1964. Limestone vegetation in Shikoku 9. Ibid. 21: 29-33. — & K. Morishita. 1956a. Limestone vegetation in Shikoku 4. Ibid. 16: 120-125.

* * * *

四国産イカリソウ属植物の23集団からサンプリングを行い、形態的変異及び花粉の稔性について調べた。その結果、現在見られる様々な集団の構成パターンの成立に浸透性交雑が関与していたものと思われる。サイコクイカリソウ、ヒメイカリソウと呼ばれる種類はバイカイカリソウとヤチマタイカリソウ(広義)との間の自然交雑を起源とし現在は比較的安定していると思われる。一方、交雑が関与していないと思われる2つの変異型が地理的に隔離されたヤチマタイカリソウの集団間に認められる。